# Commercial Transportation- Clean Choices for the 21st Century

## The Role of Advanced Diesel Technology

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*International Truck and Engine Corporation*

# Outline

- *Introduction*
- *Commercial Mobility*
- *The story of the diesel engine*
- *Successes in diesel development to date*
- *Challenges for the future*
- *Green diesel - “the brilliance of common sense”*
- *Alternative fuels -issues and challenges*
- *Conclusions*

# Commercial Mobility

- Backbone of economic development
  - Flexible and efficient transportation of materials, products, goods, people, etc. on land, railroads and water
  - Modern agriculture
  - Construction industry
  - Forestry, mining
- The engine of choice is the “diesel”

# The Story of the Diesel Engine

PATENT-URKUNDE

№ 67207

AUF GRUND DER ANGEHEFTETEN BESCHREIBUNG UND ZEICHNUNG IST DURCH BESCHLUSS DES KAISERLICHEN PATENTAMTES

an Rudolf Diesel, Ingenieur, in Berlin

EIN PATENT ERTHEILT WORDEN.

GEGENSTAND DES PATENTES IST:

GESETZ v. 7. APRIL 1891

Arbeitsverfahren und Ausführungsart für Verbrennungskraftmaschinen.

ANFANG DES PATENTES: 28. Februar 1892.

DIE RECHTE UND PFLICHTEN DES PATENTINHABERS SIND DURCH DAS PATENTGESETZ VOM 7. APRIL 1891 (REICHS-GESETZBLATT FÜR 1891 SEITE 79) BESTIMMT.

ZU URKUND DER ERTHEILUNG DES PATENTES IST DIESE AUSFERTIGUNG ERFOLGT.

Berlin, den 23. Februar 1893.

KAISERLICHES PATENTAMT.

Beglaubigt durch Klauk

Bureau-Vorsteher des Kaiserlichen Patentamtes.

**Dr. Rudolph Diesel**
**German Inventor**

# The Story Continues

- before 1914
  - Ship propulsion; stationary applications
- 1914-1918
  - Higher speed diesels; transportation
- by 1930
  - Trucks, buses, railroad engines
- 1939-1945
  - Airplanes (high supercharging), esp. Germany
- after 1945
  - Dominant in heavy road transport (esp. Europe)
  - Scaled down to agricultural and industrial applications

# The Story Continues

- by 1935
  - Diesel engines in taxicabs (in Europe)
- 1975-1990
  - US and Japan expand the diesel in transport after the 70's
  - Light/high speed diesels (NA, TC) evolving
  - In 1990 18% of cars in Europe were diesels!
- After 1980
  - Diesels subjected to emission regulations in US, then in Europe and Japan

# The Diesel Engine Today

- Undisputed “King of the Road” in Heavy and Medium Transport
- Significant in-roads in passenger cars!
  - France 60% of new cars
    40% of car population
  - Austria /Germany 30% (aprox.)
  - Europe 36%(today); 50%(by 2006)
- Topic of heated debates!

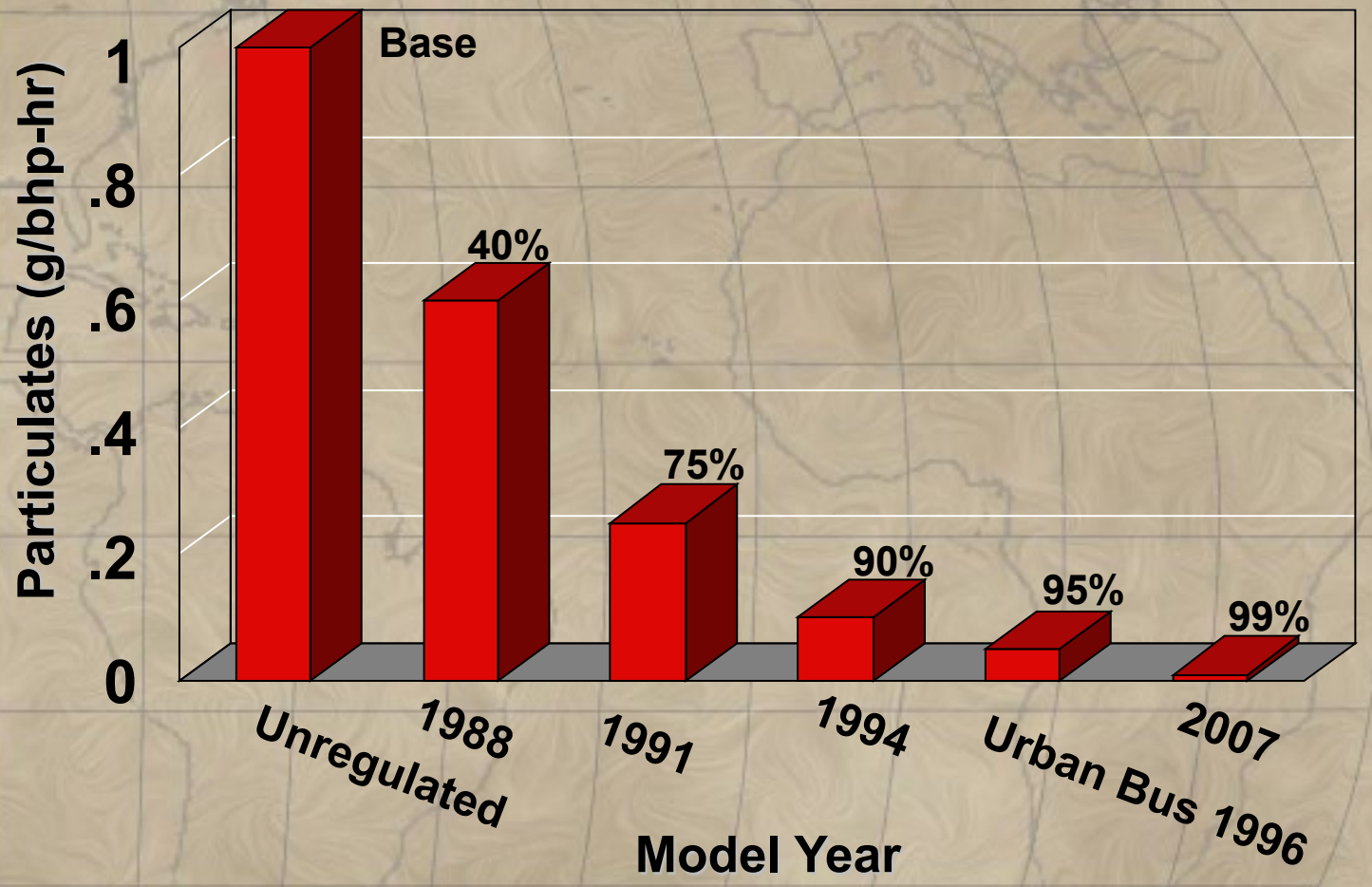
# Diesel Engine Benefits

- Fuel Efficiency and Greenhouse Gas Emissions
  - Most efficient powerplant
  - Very Low $CO_2$ emissions ; No CO emissions
- Energy Use
  - About 30% of crude oil energy is in diesel fuels
- Durability and Reliability
  - Unsurpassed by other machines
- Safe Fuel Handling
  - Fuel is not flammable

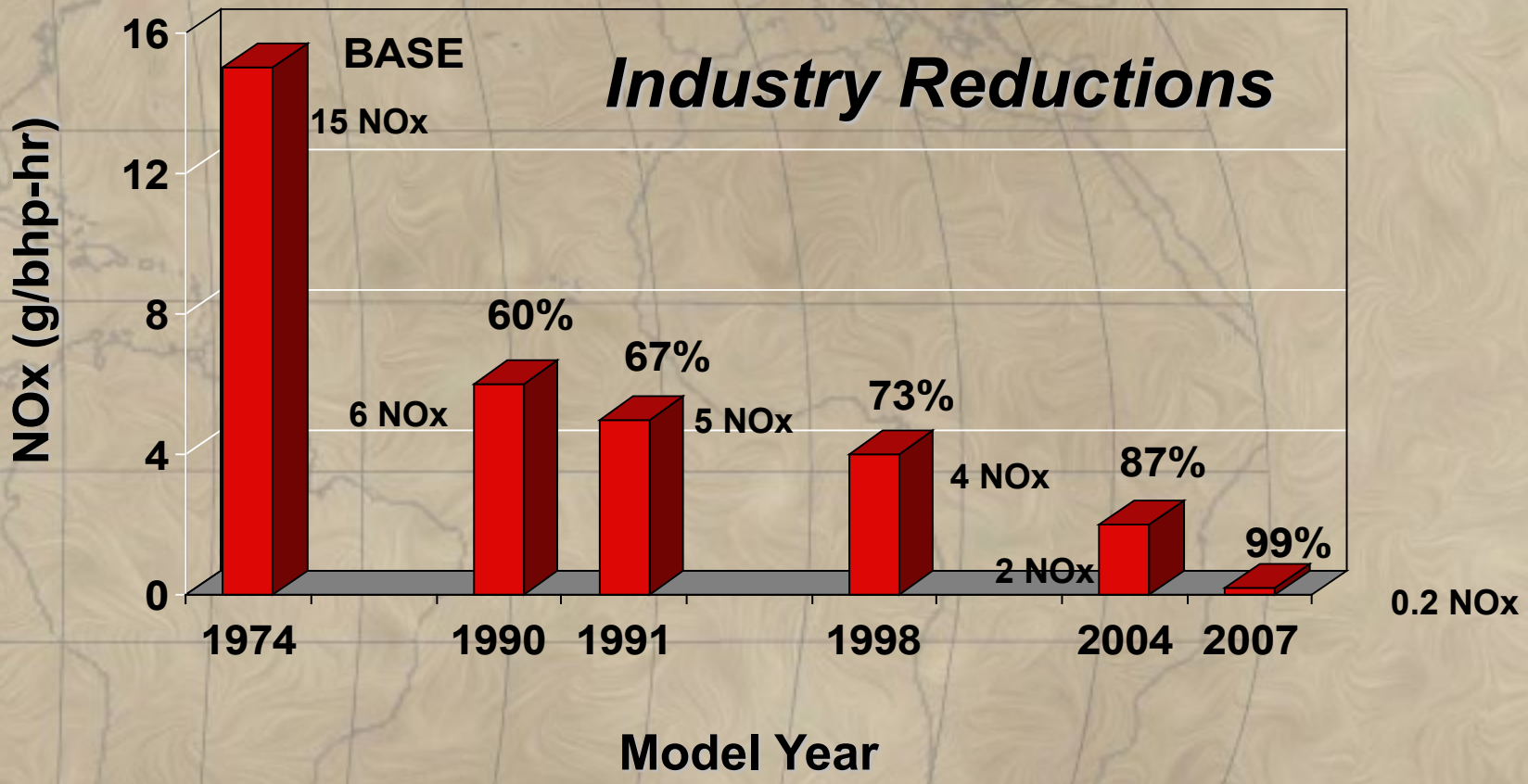
# Diesel Engine Challenges

- Technical
  - Emission profile (NOx and Particulates)
  - Emission control more difficult than in gasoline engines
  - NOx/Particulate Trade-off
- Societal
  - Benchmarked against Gasoline Engine
  - Regulatory Environment
  - Public Perception
  - Unrealistic assessment of alternatives

# Progress In Reducing HD Truck PM Emissions



# Progress In Reducing HD Truck NOx Emissions



# Diesel Progress to Date

- Significant reduction of emission levels (80-95%) while preserving and enhancing all other diesel attributes.
- "Technology trail" of success was mainly basic engine development:
  - Direct injection, high pressure injection
  - Turbocharging, air management
  - Electronic control of injection
  - Advanced combustion chambers
  - etc.

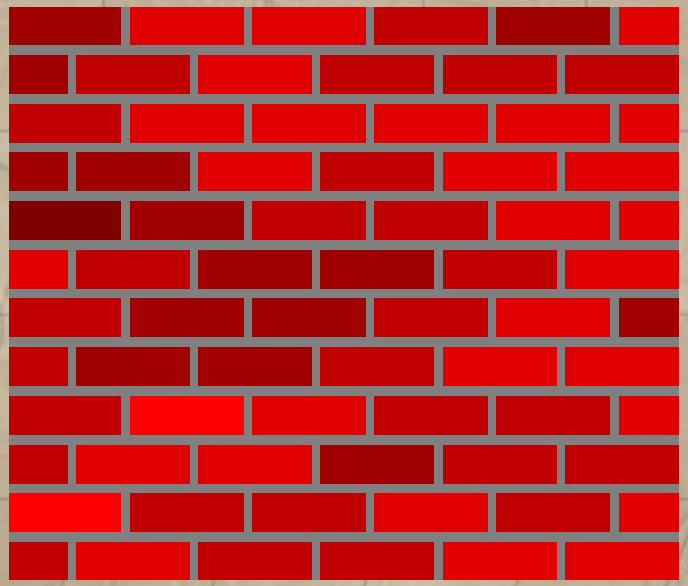
# Challenges Ahead-*2004!*

(advanced for Oct. 2002)

- Additional stringencies
  - Compliance ranges widened
  - NTE limits (flatter emission maps)
- Technology may include use of EGR and continued enhancements of basic engine

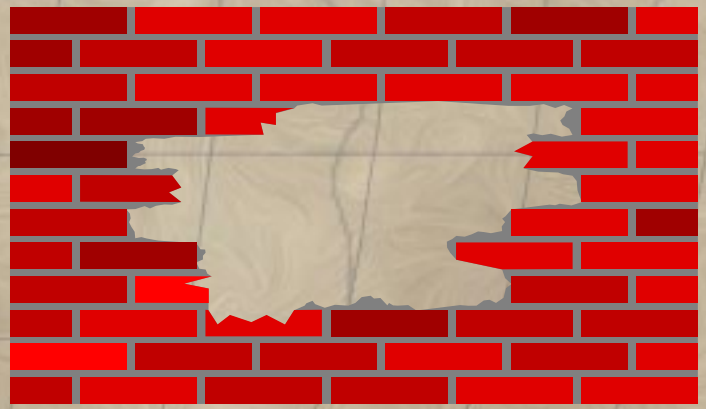
# Challenges Ahead- 2007!

- Emission Reductions of about 90% of NOx and PM Required!!!
- Technology Trail of basic engine development hits a dead end!



# Challenges Ahead- 2007!

- System approach
  - Engine-Exhaust aftertreatment- Fuel
- Advanced engine design and function
- Leverages the development of diesel catalytic systems for NOx and PM control
- Requires "sulfurless" diesel fuel



# Challenges Ahead- 2007!

- **Sulfur effect**
  - Sulfate Generation (increases PM)
  - Catalyst inhibition
  - Catalyst Poisoning

# Challenges Ahead- 2007!

- EPA Ruling will assure ultra-low sulfur (ULS) diesel fuel for on-highway applications by June 2006 (max.15 ppm)
- ULS fuel is already available today in some markets to support early demonstrations of clean diesels!

# Enter Advanced Diesel!

# Industry Moving Ahead!

- Diesel Engine Industry and Catalytic Systems Companies working intensively to develop the technology for 2007!
- Early Introductions!
- International's approach:

  Green Diesel Technology™

# Why Green Diesel Technology ™

- Demonstrate that alternative-fuel emission levels can be achieved by advanced diesel technology
- Demonstrate the emissions reductions that can be achieved with ultra-low sulfur fuel (technology enabler)
- Provide an answer to public health concerns associated with particulate matter and toxic hydrocarbons
- GDT certified in 50 states (03/12/2001)

# Advanced Diesel Cleaner than CNG! 2002 Results by CARB

- **Application** - urban bus
- **Contenders** - CNG engine
  - diesel engine w/ ultra low sulfur and DPF
- **Sponsor** - California ARB
- **Results**
  - Mutagenicity of exhaust higher for the CNG engine!
  - In 8 out of 11 pollutant criteria the diesel had lower emissions than the CNG engine!
- **Several studies in the industry support similar conclusions!**

# Diesel Toxicity Issue

# Alternative Fuels for Diesel Engines

- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)
- Biodiesel
- Dimethylether (DME)
- Syntethic Diesel (FT fuel/GTL fuel)
- Alcohols (methanol, ethanol)
- Blends (diesel/water, diesel/alcohol)

# Alternative Fuels for Diesel Engines

- Driving forces
  - Emissions (before)
  - Domestic resources
  - Long term potential when crude oil is depleted
- Challenges
  - Availability, Infrastructure
  - Technology maturity
  - Cost
  - Fuel Quality
  - Emissions?

# Other Technologies in the Works for Future Commercial Transportation

- **Short-Medium Term (5-10 years)**
  - Hybrid (diesel/electric) powertrain excellent “well-to-wheel” greenhouse gas potential!
- **Long Term (15 + years)**
  - Fuel cell technology (hydrogen based) best “well-to-wheel” greenhouse gas potential only when renewable energy is used to generate hydrogen!

# Conclusions

- Environmental and energy considerations will continue to drive the development of Diesel Technology.
- Hybrid Diesel Technology may extend the applications of diesel engines in the future (passenger cars as well as urban trucks)
- As long as crude oil is available the advanced diesel technology will be hard to beat!

but…

# Conclusions (cont'd)

- Emerging technologies may evolve and their progress may bring about competition to the diesel
- Fuel cells may come into vehicular applications, but will likely appear first as auxiliary power units in heavy trucks

# Conclusions (cont'd)

- Light Duty Diesel Technology is leading in progress

- Its achievements will be applicable to Heavy Duty Engines

# Conclusions (cont'd)

- Despite its venerable age, the Diesel Engine is evolving!
- The "Diesel Paradigm" has shifted!
- We are witnessing the "Greening" of Diesel Technology!

# The Vision !

*“ by 2007, the diesel technology will be as clean or cleaner than any other alternative fuel technology!”*

**Carroll Browner**
**(former EPA Administrator)**

And in his wildest dreams,

Mr. Rudolf Diesel could not have imagined that!